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ABSTRACT

In simultaneous learning two verbal lists are interlaced for study, with each tested separately. In the present experiments simultaneous learning was used as a means of determining the conditions under which study time or learning resources might be reallocated between lists. One of the lists was called the standard list and remained constant across the conditions of each experiment. The other list, the variable list, was manipulated to produce differences in its difficulty. If performance on the standard task varied as a function of the difficulty of the variable list a shift in study time was inferred. In one experiment the variable task difficulty was changed by manipulating word frequency, stimulus similarity, concreteness, and meaningfulness. These manipulations had little influence on performance on the standard task. However, in another experiment when words were repeated in the variable task, more time was given to the standard. When subjects knew that the variable task was to be tested for recognition they gave less study time to it than when a recall test was to be given. It was concluded that subjects reallocate study time between two tasks being learned simultaneously only when there are obvious differences in difficulty. (Author/RL)

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The Effect of the Difficulty of One Task on the Simultaneous Learning of Another Task

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Northwestern University

August, 1960

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In simultaneous learning two verbal lists are interlaced for study, with each tested separately. In the present experiments simultaneous learning was used as a means of determining the conditions under which study time or learning resources might be reallocated between lists. One of the lists was called the standard list and it remained constant across the conditions of each experiment. The other list, the variable list, was manipulated to produce differences in its difficulty. If performance on the standard task

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varied as a function of the difficulty of the variable list, we inferred a shift in study time. In a more general sense, the purpose of the experiments was to determine the strategies that a subject might use to maximize the learning when the instructions are to learn as many items from both lists as possible.

In one group of experiments the variable task difficulty was changed by manipulating word frequency, stimulus similarity, concreteness, and meaningfulness. These manipulations had little influence on performance on the standard task. However, it was found in another group of experiments that when words were repeated in the variable task, more time was given to the standard. This was also true when preliminary practice was given on the variable list. Further, when subjects knew that the variable task was to be tested for recognition they gave less study time to it than when a recall test was to be given.

In addition, one of the studies suggested the possibility that when the processes underlying the two tasks are uncorrelated, performance on both tasks is enhanced. Another study indicated support for the theory which asserts that the spacing effect is due to an attenuation-of-attention for massed items. Our general conclusion is that subjects reallocate study time between two tasks being learned simultaneously only when there are obvious differences in difficulty.

The Effect of the Difficulty of One Task on the Simultaneous Learning of Another Task

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The Effect of the Difficulty of One Task on the Simultaneous Learning of Another Task

In what we will call simultaneous learning, the subject is given two or more verbal lists to learn together. Each study presentation consists of an item from each list. Thus, if there were three different lists the subjects would see three items, one from each list, for a given period of time, after which another three items would be shown, and so on. On test trials the subjects are tested on each list separately. The lists are made up so that they are clearly distinguishable from each other and the subjects are instructed concerning the ways in which the lists differ. Under these conditions there appears to be little interference among the items in the different lists.

Most of the studies to be reported deal with the allocation of study time by the subject when two lists are learned simultaneously. Assume, for example, that one of the lists consists of very easy words, the other of very difficult words. The subjects are free to allocate the study time as they see fit. It would seem that they might well spend more time studying the difficult words than the easy words when they are instructed to learn as many words from both as possible.

One of the two lists will be called the standard list and it remains constant across all conditions within an experiment. The other list will be called the variable list because across conditions it is changed so as to vary the difficulty. In the different experiments to be reported the dimension used to manipulate difficulty varies. The essential question is whether or not the subjects will allocate time differentially to the

tasks as the difficulty of the variable task changes.

It would seem reasonable to predict that the more difficult the variable task the less the time allocated to the standard task. Hence, the more difficult the variable task the poorer the performance will be on the standard task. To say this another way, the average subject might be expected to try a strategy in which the time spent studying the standard task differs as a function of the difficulty of the variable task. The consequence of this strategy will be seen in the rate at which the learning occurs on the standard task.

The above situation can be viewed in several quasi-theoretical ways. One way is to think of there being a limited intake capacity for a given period of time. There is no reason to believe that the memory system has a limited capacity or limited memory space given an infinite amount of time to learn. But in terms of the restricted amounts of time we use in learning experiments, there is clearly a finite intake capacity for a given individual; only so much can be learned in a specified amount of time. The subject, in learning tasks simultaneously, may therefore allocate his study time differentially across the tasks based on the perception of relative difficulty.

Another way of viewing the situation is in terms of the learning resources available (Norman & Bobrow, 1975). The subjects may allocate the resources differentially across tasks, thus producing differences in the rate at which the standard task is learned as a function of the difficulty of the variable learning task. It can also be seen that the concept of attention could be brought in, and we could speak of differences

in attention (e.g., Kahneman, 1973) given to the two tasks as being the immediate cause for differences in the learning of the standard task.

As may be inferred from the above, there has in fact been a rather large amount of work in recent years dealing with performance on more than one task, and particularly dealing with concepts that might be used in describing and conceptualizing dual-task performance (e.g., Navon & Gopher, 1979). However, we have been unable to find systematic data that bear directly on the question we are raising about the effect of variations in difficulty of one task on the performance on another task being learned simultaneously. The most commonly used two-task situation is one in which the difficulty of a series of tasks is gauged by the reaction time to a neutral stimulus presented during performance on the other task. However, this situation differs considerably from the one we are dealing with. First, of course, is the fact that the auxiliary task (reaction time) is not a learning task. More important is the fact that the subjects are clearly instructed to the effect that the reaction-time task is secondary and that the performance on the other task must be maintained even if the reaction times are severely degraded. Hawkins and Ketchum (1980) have raised some serious questions about this reaction-time technique, and it is a fact that in some situations at least it appears that the more difficult the central task the shorter the reaction time (Britton, Westbrook, & Holdredge, 1978).

In view of the lack of evidence on the situation with which we will deal, we will initially take a very simple approach. I[illegible]as the variable task changes in difficulty, there is a change in performance on the standard

task, we will simply assume that the subjects have made changes in the allocation of study time for the two tasks. The experiments were designed to determine under what conditions such a change in allocation does in fact occur.

Experiment 1

In the first experiment there were two manipulations designed to vary the difficulty of the variable list. The first manipulation consisted of varying the number of different words to be learned as the variable list, keeping the total number of presentations constant. At one extreme, 36 different words were presented for study one time each, while at the other extreme there were nine different words each presented for study four times each. The standard task consisted of 36 different words, each presented once, under all conditions. The empirical question was whether the rate of learning the standard task would differ as a function of the number of different words appearing in the variable list.

The second way of manipulating the difficulty of the variable task was to have it tested either by recall or by recognition. Before presenting the lists for study, the subjects were fully informed as to how they would be tested on both lists. We assumed in a naive way that the subjects would expect a recognition test to be easier than a recall test. As a consequence, they might allot more study time to items in the standard task (which was to be recalled) when the items in the variable list were to be recognized than when they were to be recalled.

Method

Lists. Two sets of words were used, one set consisting of five letter, high-frequency (AA or A) words, the other of three-letter words of the CVC structure, and varying widely in frequency. The five-letter words will be spoken of as L5, the three-letter words as L3. The L5 words were always used as the words to be recalled as the standard task. The L3 words were always used as the standard task when the standard task was tested by recognition. There were always 36 words in the standard task, whether L3 or L5. The instructions to the subjects emphasized the distinction between L5 and L3 in terms of the number of letters as a means of discriminating between the items in the two lists.

Conditions. We will refer to the recall tests by the letter R, and to the recognition tests by the letter D. Letting the first letter symbolize the standard task, and the second the variable task, there were four combinations: RR, RD, DD, and DR. Thus, in Condition RR, the standard list (L5 words) was recalled, as was also the variable list (L3 words). In Condition RD the standard list (L5 words) was recalled but the variable list (L3 words) was tested for recognition. In Condition DD, both lists were tested for recognition, the standard list being made up of L3 words, the variable list of L5 words. Finally, in Condition DR the standard list (L3 words) was again tested for recognition whereas the variable list (L5 words) was tested by recall. It should be noted that we were not interested in comparing retention of the two sets of words (L3 and L5). Rather, we were interested in the recall and recognition of the standard list as a function of the type of memory test given on the variable list, and as a

function of the number of different words used in the variable list, a manipulation to which we now turn.

There were three levels of repetition designed to vary the difficulty of the variable task. These levels were 36/1, 18/2, and 9/4, where the first number represents the number of different words in the list, and the second number the number of times each word was presented for study. Thus, there were always 36 presentations but the number of different words changed across conditions. These conditions will be identified in terms of the number of times each word in the list was presented for study (1, 2, and 4). The three levels of frequency of presentation were crossed with the four recall-recognition combinations (RR, RD, LD, DR) to produce 12 different conditions, although we will not analyze the results as a 3x4 experiment.

Finally, there were two control conditions in which only a single list was learned. In one case the L5 list was used and it was tested for recall, in the other the L3 list was used and it was tested by recognition. The purpose of these controls was simply to demonstrate what may seem obvious, namely, that two lists presented simultaneously results in less learning of either task than is observed if each task was presented alone at the same rate of exposure.

Procedure and subjects. Except for the control conditions, there were always two words presented simultaneously, one L5 and one L3. The two words were presented on slides, both on the same line, with the order being random. The study period for each slide was 5 sec for all conditions. The subjects were fully informed about the nature of the tests, about the

items in the two lists being different in terms of number of letters, and so on. The standard list was always tested first. The recall test was free recall with 2 min allowed. On the recognition test only nine words were tested, but each appeared in a row of six other new words. The nine words used for the tests consisted of nine words that occurred in all frequency conditions (1, 2, and 4). The new items on the forced-choice tests were drawn randomly from the L3 and L5 pools. The subjects were given as much time as needed to make their recognition decisions, and they were required to choose a word from all nine sets, guessing if necessary.

The learning always consisted of two trials. The second trial began immediately after the variable list was tested on the first trial. The second trial was an exact replication of the first in terms of ordering of the items on study, type of test, and so on.

Group procedures were used to collect the data with a maximum of six subjects being tested in a group. In the initial stages of testing, six subjects were scheduled for each session. Because 36 subjects were to be assigned to each of the 14 conditions, we constructed a block-randomized schedule of the 14 conditions with each occurring six times. Groups were assigned to conditions from this schedule in order. The failure of some subjects to appear when scheduled made it necessary to add subjects to make 36 in each condition. These additions occurred only after the initial testing of all 84 groups.

Results and Discussion

Conditions RR and RD. These two conditions both required the recall

of the standard task (15 words). We will first examine the results for Condition RR as seen in the left panel of Figure 1. The recall measure is given as a percent (of 36 possible). The abscissa gives the frequency per word on the study trial of the variable task. The rejection level for the null hypothesis was $p < .05$. The first fact to note is the not surprising finding that recall for the control condition was far ahead of the recall under simultaneous learning, the means for the control being 43.03 and 66.06 for Trials 1 and 2. A second fact to note is that the frequency variable had little influence on Trial 1, but did have an influence on Trial 2; performance increased as the frequency increased. The results of a statistical analysis were quite in line with the picture given in Figure 1; the frequency variable was reliable, $\underline{F}(2, 105) = 4.27$, $MS\underline{e} = 255.09$, as was also the interaction between frequency and trials, $\underline{F}(2, 105) = 7.21$, $MS\underline{e} = 41.92$.

Turning to the results for Condition RD in the right panel of Figure 1, we can see that the frequency variable had very little influence, $\underline{F}(2, 105) = 2.18$, $MS\underline{e} = 265.62$. This is to say that the frequency of repetition of the words in the variable task had essentially no influence on the recall of the standard task when the words in the variable task were tested by a recognition procedure. Nevertheless, as may be observed in Figure 1, the recall is higher on both trials for Condition RD than for Condition RR. Summing across trials it was found that the difference was reliable, $\underline{F}(1, 210) = 14.25$, $MS\underline{e} = 520.71$. When the subjects expected and

received a recognition test on the variable task, recall of the standard task was higher than if a recall task was given on the variable task.

Condition DD and DR. The response measure used for recognition was the mean number of errors (out of nine possible). These scores are plotted in Figure 2. The mean numbers of errors for Trials 1 and 2 for the control condition were 1.97 and 1.17. These values again indicate the obvious fact that simultaneous learning of two tasks occurs more slowly than the learning of a single task presented for the same study period.

Figure 2 indicates that there were no systematic relationships between frequency per word of the variable task and recognition performance on the standard task. Separate analyses for Condition DD and Condition DR showed that only trials was a significant source of variance. Figure 2 may suggest that performance is generally poorer under Condition DR than under Condition DD, but this has no statistical support, $F(1, 210) = 3.29$, $MS_e = 13.25$. We may conclude that manipulation of the difficulty of the variable task (whether recalled or recognized) had no influence on the recognition of the standard task.

Variable lists. The frequency manipulation was carried out as a means of varying the difficulty of the variable lists. We need to consider briefly the performance on the variable tasks. In Condition RR the recall of the L3 words increased directly as frequency increased, the values on the second trial being 32.8, 55.4, and 84.4% for the frequency conditions 1, 2, and 4, respectively. The recognition scores for the variable list

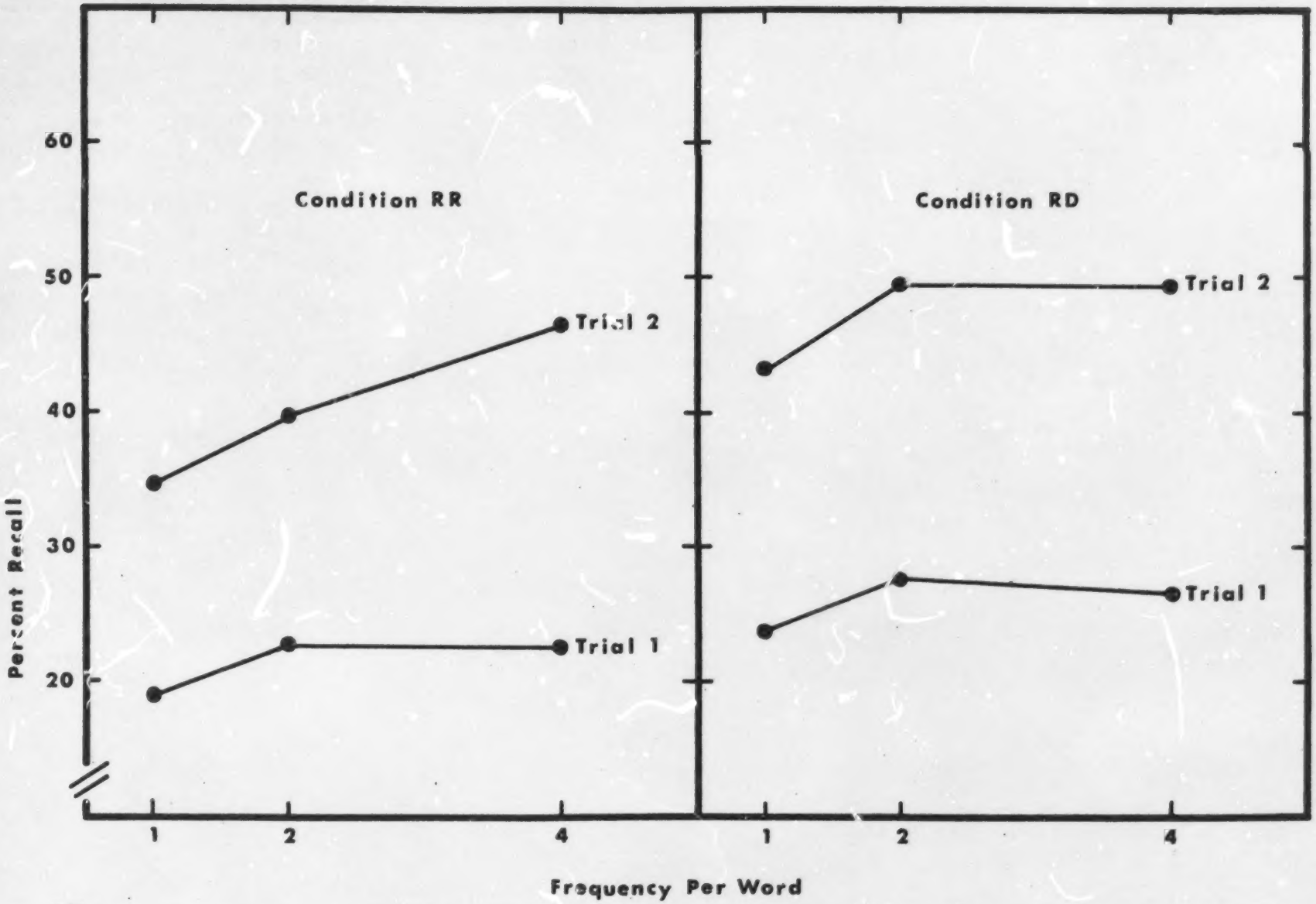

Figure 1. Percent recall of the standard list in simultaneous learning as a function of the frequency of items in the variable list, trial, and condition. In Condition RR both lists were recalled, while in Condition RD, the standard list was recalled, the variable list was tested by recognition. Experiment 1.

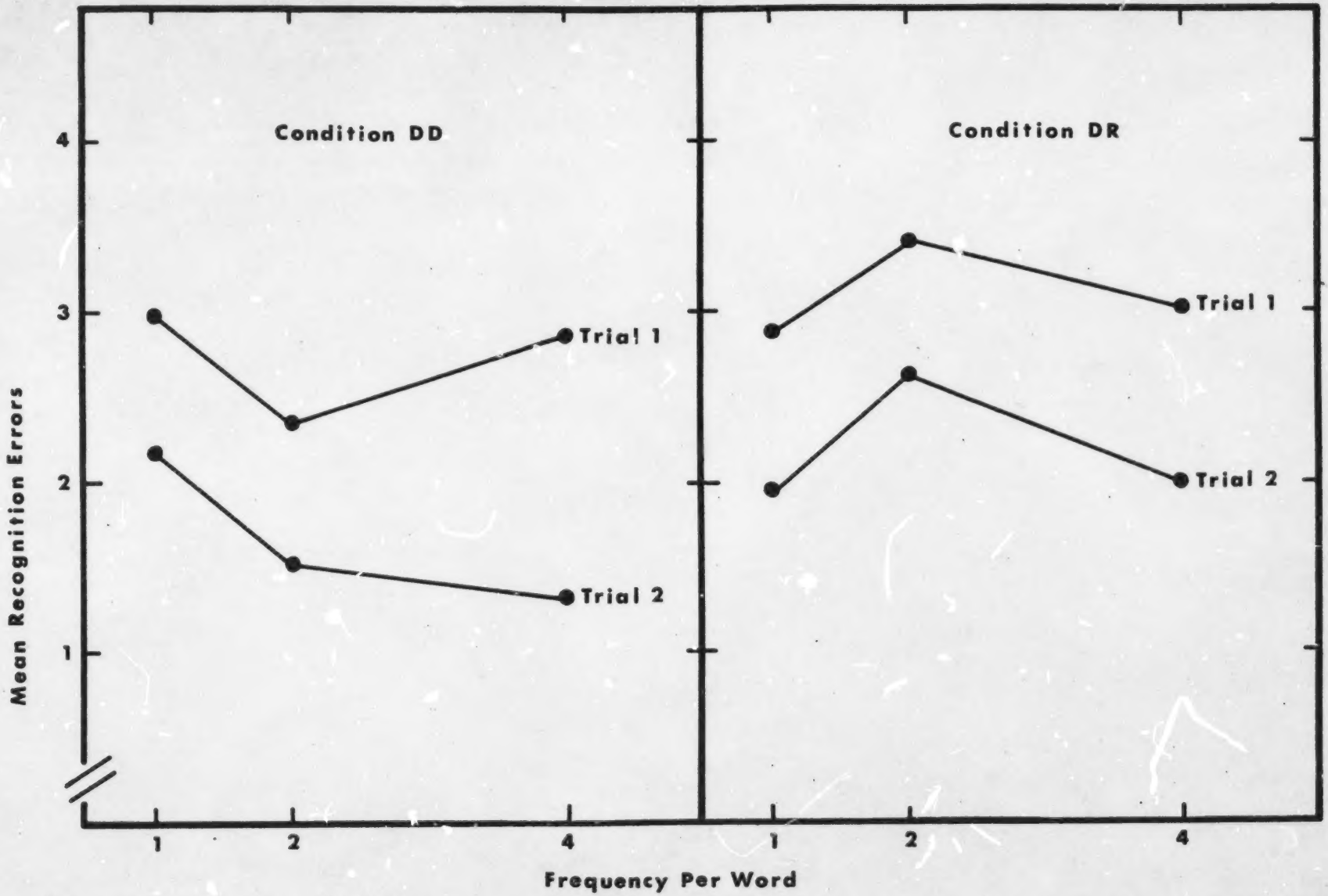

Figure 2. Recognition errors on the standard list during simultaneous learning as a function of the frequency of the items in the variable list, trial, and condition. In Condition DD both lists were tested by recognition; in Condition DR the standard list was tested by recognition, the variable list by recall. Experiment 1.

for Condition RD for the second trial were 2.94, 1.83, and .31 for the three frequency conditions in order.

For Condition DD the recognition scores on the variable list on the second trial were 2.58, .94, and .19 for the frequency conditions of 1, 2, and 4, respectively. The recall scores for Condition DR on the second trial were 38.1, 63.7, and 92.7% for the three frequency conditions. It is abundantly clear than wide differences in learning the variable task resulted from the frequency manipulation. Nevertheless, the effect on the standard task was completely absent when the standard task was a recognition task, and the effects were relatively small, although statistically reliable, when the standard task was recalled.

In the recognition tests for the standard task there was no evidence that variations in the difficulty of the variable task influenced performance. These data seem to indicate that the learning resources or learning space required when items are repeated is as great as when all items are new items. Under these circumstances, the subjects did not reallocate study time despite the fact that it must have been apparent that performance on the variable task (when item repetition was heavy) would be far better than performance on the standard task.

The above interpretation given for the recognition tests on the standard list does not handle adequately the data when recall is required on the standard task. Subjects apparently did reallocate study time between Trials 1 and 2 when recall was required on both tasks, and the amount of reallocation was directly correlated with the frequency of repetition of the words in the variable task. This evidence might suggest that a subject

can better evaluate his learning of recall tasks than of recognition tasks. The evidence also suggested that in Condition RD the subjects gave more study time to the recall task than to the recognition task under all conditions. However, the subjects apparently did not do this in Condition DR, although the differences were in the proper direction. Thus, for the time being, we must leave as ambiguous the findings with respect to recognition tests versus recall tests. Subjects in two conditions did appear to allocate more time to the recall task than to the recognition task, but the statistical support was present in only one of the conditions.

Experiment 2

The difficulty of the variable task in Experiment 2 was manipulated by changing the background frequency of the words. Only recall was used and it is presumed that the ease of learning the task is directly related to background frequency. The empirical question was again whether performance on the standard task would be influenced by the word frequency of the variable list being learned simultaneously.

Method

Lists. The standard list consisted of 24, two-word fictitious company names, e.g., Premier Drugs, Victor Carpets. The variable lists differed in terms of word frequency as indexed by Thorndike and Lorge (1944). List L consisted of 24 words with frequencies of less than one per million. Many of these words would probably not be judged to be words by college students (e.g., abysm, hawse, shoon). The words in List M (medium frequency) had frequencies of one per million, and those in List H were A or AA words. All words had five letters. The items of each of the three lists

were paired randomly with the 24 company names to form three different lists to be presented for simultaneous learning.

Procedure, Conditions, and Subjects. There were four conditions, three of them representing simultaneous learning as noted above and which will be identified by the frequency of the variable list (L, M, H). The fourth condition, a control condition, consisted of learning the three variable lists alone to determine the relationship between word frequency and free-recall learning for these three lists.

There were four groups of 36 subjects each, corresponding to the four conditions. The control subjects were given two study-test trials on each of the three single lists. The order of learning the lists was counterbalanced so that six subjects were assigned to each of the six possible orders. Two study-test trials were also given on the three lists learned simultaneously. In all cases the standard list was recalled first. The presentation rate was 5 sec for all four conditions and 2 min were allowed for the recall of each list. There were 36 subjects in each of the four conditions and group testing was used following the procedures described for Experiment 1.

Results and Discussion

On Trial 1 the means numbers of correct responses for the L, M, and H control lists were 8.25, 9.56, and 14.78, respectively; the corresponding values on Trial 2 were 14.52, 15.89, and 19.94. An analysis of variance for the scores summed across trials showed the frequency variable to produce reliable effects, $F(2, 70) = 77.75$, $MS_e = 9.10$.

The recall of the standard task (company names) as a function of the

frequency of the words being learned simultaneously is shown in Figure 3. Any shifting of resources as a function of word frequency would lead to the expectation that performance on the standard task would increase as word frequency increased. Obviously this did not occur. Actually, the data for Trial 2 show an opposite trend although statistically there was no influence of word frequency.

The learning of the variable task during simultaneous learning produced an unexpected finding, namely, that learning was not related to word frequency on the first simultaneous learning trial. The mean numbers correct were 3.06, 3.72, and 2.89 for L, M, and H, respectively. On the second trial the values were 6.06, 6.89, and 7.69. The interaction between trials and frequency was reliable, $F(2, 105) = 8.83$, $MS_e = 2.03$. We do not know why the effect of word frequency on learning was so sharply diminished initially during simultaneous learning as compared with single-list learning. However, we recognize the possibility that the fact that the learning of the standard task did not differ as a function of word frequency was because word frequency did not produce a variable task that differed appreciably in difficulty.

Experiment 3

Runquist (1978) constructed two paired-associate lists of 12 pairs. The two lists had six pairs in common, these pairs consisting of nonsense shapes as stimulus terms and two-digit numbers as response terms. The other six items were made up of consonant trigrams as stimulus terms and

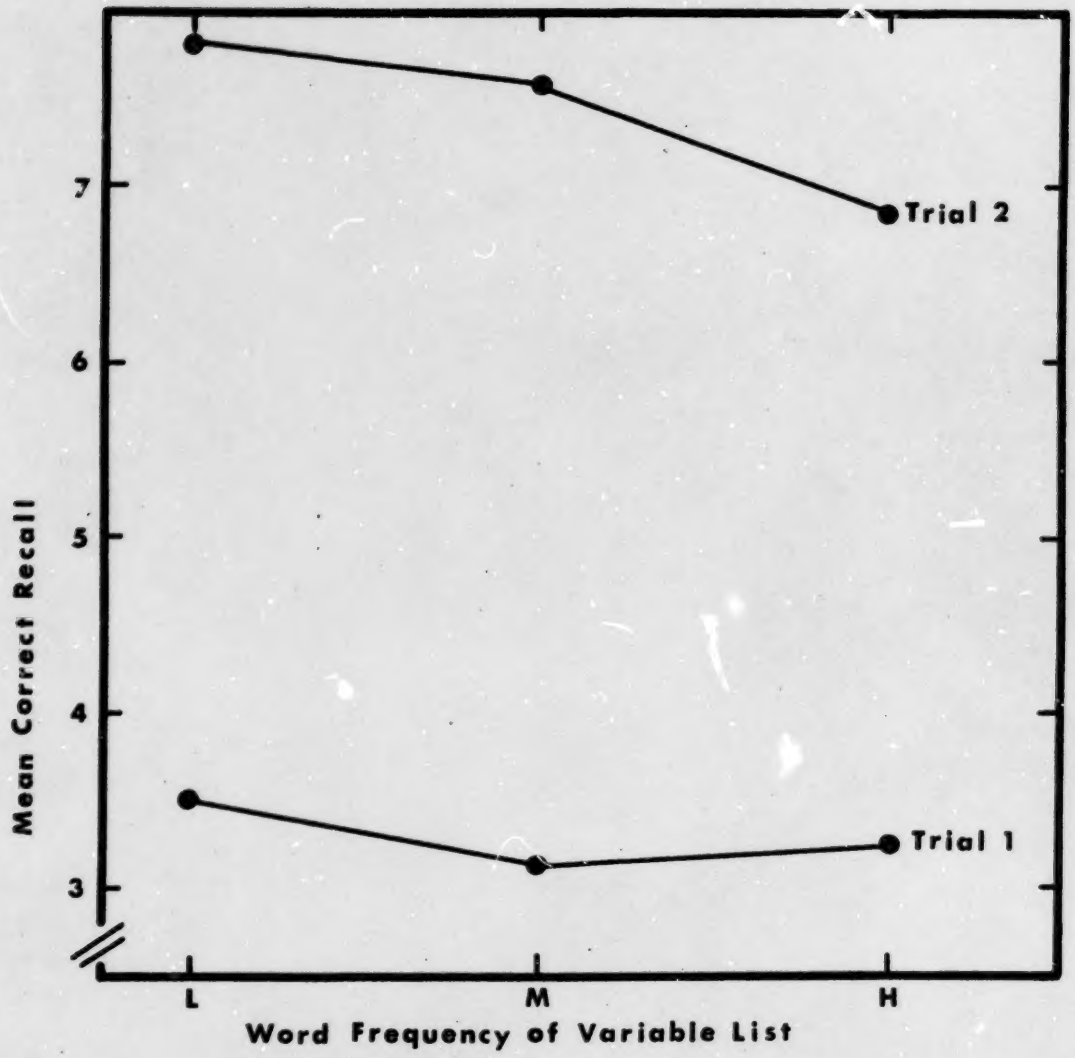

Figure 3. Recall of the standard list as a function of the word frequency of the variable list. Experiment 2.

nouns as response terms. For one list, however, the six syllables had high formal similarity, those for the other list low formal similarity. Each list was presented for 15 study-test trials. Runquist reports wide differences in learning the CCC-noun pairs as a function of similarity, but that there was no difference in learning the shape-number pairs. In terms of the language we have used in reporting the first two experiments, the CCC-noun pairs represent the variable list, the shape-number pairs the standard list. The difference between Runquist's procedures and ours is that we use simultaneous learning whereas Runquist used regular single-item presentation of the pairs. The question we ask in Experiment 3 is whether production of differences in difficulty of the variable list by manipulating interstimulus similarity will influence performance on the standard task.

Method

Lists. The standard list consisted of 24, two-syllable words, having AA frequency. This list was always tested by free recall. The other three lists (the variable lists) each consisted of 12 pairs in which the stimulus terms were three-letter words having CVC structure, and the response terms were the numbers 1-12. The 12 words in the low-similarity lists (LS) were made up of 5 different vowels and 18 different consonants. The words in the medium-similarity list (MS) were made up of 4 different vowels and 11 different consonants, while the high-similarity list (HS) contained only 3 different vowels and 6 different consonants.

As noted above, there were 24 words in the standard list. To construct the lists for simultaneous learning, each paired-associate occurred

twice on the study trial. The pairings of the words in the standard list and the paired-associates was done randomly for each of the three paired-associate lists. The simultaneous lists were presented on slides with the two items on a slide being placed one above the other on a random basis.

Procedure and subjects. As usual, the subjects were fully instructed concerning the two classes of materials and that there would be two study-test trials. They were instructed to learn as many correct responses from both classes of materials as possible during the study periods. The standard list was always tested before the variable list. The simultaneous lists were presented at a 5-sec rate, with 2 min allowed for free recall of the standard list. On the test for the variable list, the 12 stimulus words occurred in random order on a test sheet with a blank after each. The subjects were allowed 2 min to fill in the blanks with the numbers 1-12. Guessing was encouraged but not required. Group procedures were again used to collect the data, with 36 subjects assigned to each of the three lists.

Results and Discussion

The essential results are shown in Figure 4 in which free recall of the standard list is plotted against the stimulus similarity of the variable list. Although performance on the standard list did decrease as stimulus similarity increased (as might be expected), the effects were far from being reliable statistically, $F(2, 105) = 1.94$, $MS_e = 27.95$.

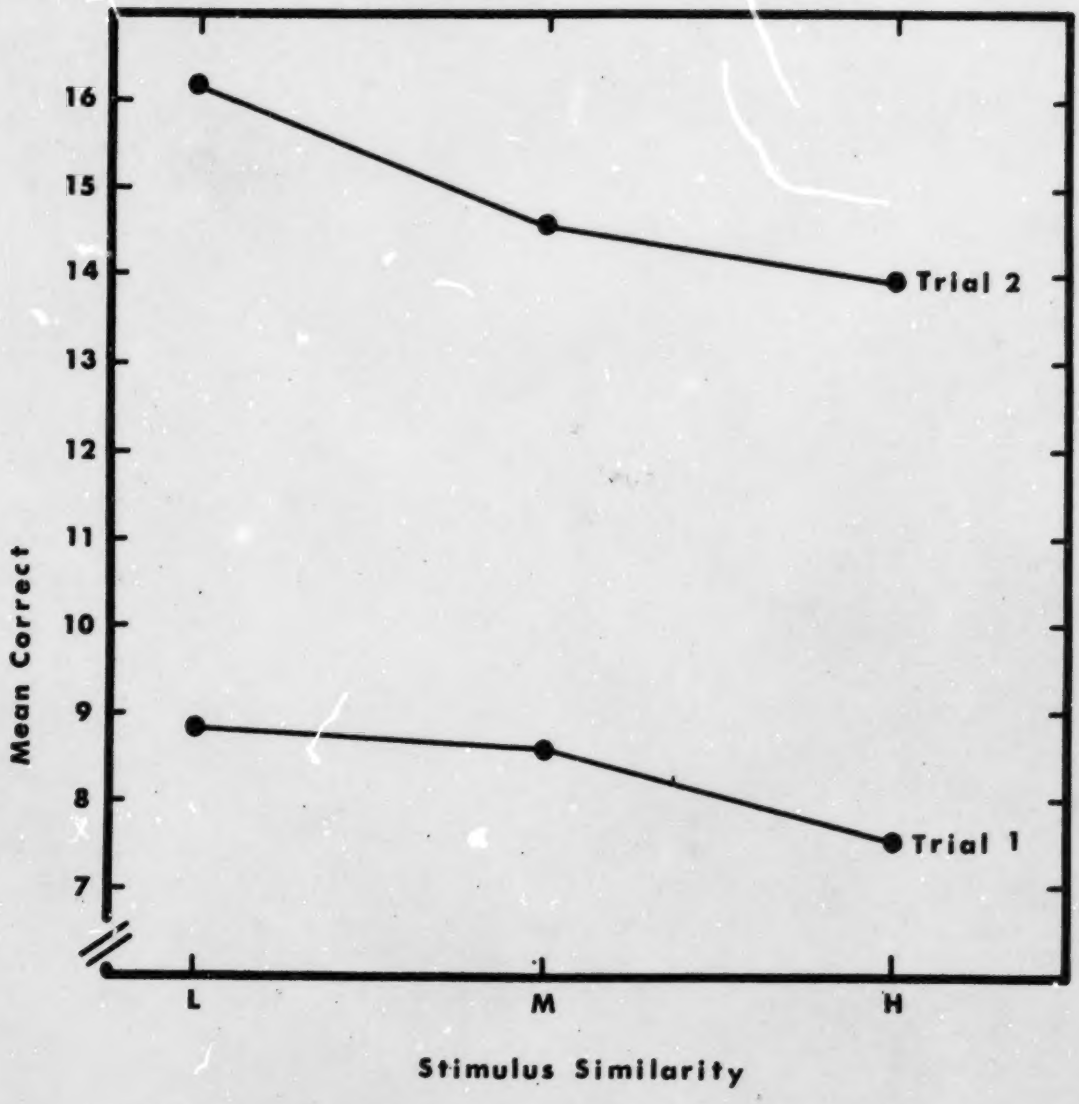

Figure 4. Correct recall of the standard task as a function of the stimulus similarity of the variable task. Experiment 3.

Differences in the recall of the paired associates on the second trial were rather sharply curtailed by ceiling effects. On the first trial the mean numbers of correct responses were 8.78, 7.58, and 6.75, for the low, medium, and high similarity, respectively, $F(2, 105) = 4.11$, $MS_e = 9.10$. Thus, stimulus similarity produced its expected effect on paired-associate learning but the variations in difficulty had little influence on the time or resources committed to the free-recall task given simultaneously. Our results thus fully confirm Runquist's (1978) results.

Experiment 4

In Experiment 1 we found that performance on the standard recall task increased as the number of repetitions of the words in the variable task increased. We interpreted this to mean that there was a shift of learning resources or study time from one list to the other. In none of the other experiments has such a shift occurred when the difficulty of the variable list was changed by means other than occurrence frequency. Experiment 4 involves a manipulation that is similar to the one used in Experiment 1. The subjects were given the variable list for study prior to simultaneous learning. Four different groups were used in which the number of variable-list learning trials differed, namely, 0, 1, 3, and 5. The empirical question remains the same; will there be a shift in resource allocation as the number of preliminary learning trials increases?

Method

Lists. The standard and variable lists were the same as those used

in Experiment 1, the standard list consisting of 36 five-letter words, the variable task of 36 three-letter words.

Procedure and subjects. The group procedures used were the same as for Experiment 1. The four conditions will be identified as Conditions V0, V1, V3, and V5, where the number indicates the preliminary trials given on the variable list alone before the two lists were combined for simultaneous learning. The 36 three-letter words were presented at a 3-sec rate for study, with 2 min allowed for free recall. Two study-test trials were given on simultaneous learning, the rate being 5 sec. Again, the standard list was recalled first followed by the variable list, with 2 min allowed for each. A total of 30 subjects was assigned to each of the four conditions by the procedures described for Experiment 1.

Results and Discussion

In Figure 5 we have plotted the mean number of correct responses on the standard task as a function of the number of preliminary learning trials on the variable task. As can be seen, the standard list was markedly influenced by the preliminary learning; the greater the number of preliminary trials the higher the level of learning on the standard list. The statistical analysis showed that the number of trials produced a very reliable effect, $F(3, 116) = 11.89$, $MS_e = 67.97$, and that there was a reliable interaction between the number of trials on the variable task and trial number, $F(3, 116) = 3.16$, $MS_e = 7.26$. This is presumably

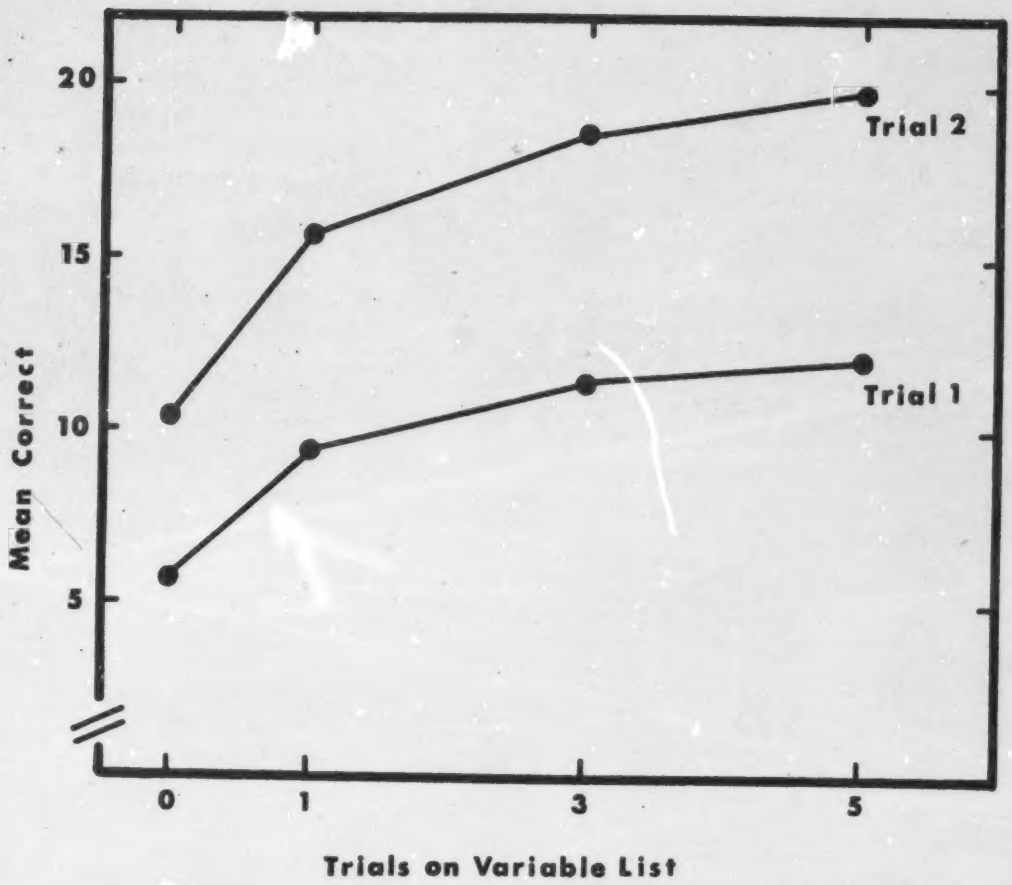

Figure 5. Correct recall of the standard task as a function of the number of preliminary learning trials on the variable task. Experiment 4.

due to the relatively small difference between the two trials when the variable list had not been given preliminary learning trials, and the relatively large differences between the two trials when the number of preliminary trials was large.

We interpret the results to mean that when simultaneous learning was given the subjects they allocated learning time disproportionately between the two lists; the greater the number of preliminary trials on the variable list the greater the time allotted to the standard list in simultaneous learning. If this interpretation is correct, it must follow that the variable task suffers somewhat during simultaneous learning. For Condition V1 (one preliminary learning trial on the variable task), the mean number of correct responses on the preliminary trial was 12.07; on the two simultaneous learning trials the values were 12.93 and 16.27. The values indicate that for this condition further learning of the variable task did occur on the simultaneous learning trials, although the amount was quite small. For Condition V3, the mean number correct on the third preliminary learning trial was 23.00, and on the two simultaneous learning trials, 20.50 and 22.17. Thus, the subjects failed to increase their recall of the variable task on the two simultaneous learning trials for Condition V3. Finally, for Condition V5, the number correct on the fifth preliminary learning trial was 28.07, and on the two simultaneous learning trials the values were 27.13 on both trials. The subjects actually lost about an item. These data indicate strong support for the idea that there is a shift of learning resources during simultaneous learning as a consequence of the prelimi-

nary learning trials given on the variable task.

Experiment 5

Thus far the learning of the standard list during simultaneous learning has not been influenced by the manipulation of intrastimulus similarity and word frequency of the variable list. One possibility for this failure is that the differences in difficulty of the variable task were relatively small. For the present experiment we chose a variable that is known to produce very marked effect in learning, namely, meaningfulness. At one extreme we used zero association value nonsense syllables and at the other we used common three-letter words. At these extremes we fully expected to produce large differences in learning the variable list.

Method

Lists. The standard list was the 36 five-letter words used in Experiments 1 and 4. The variable list consisted of 18 items, each occurring twice on each study trial. For Condition 0 the 18 CVCs had association values of zero (Glaze, 1928), and for Conditions 50 and 100, the association values were 50% (approximately) and 100%. The fourth condition, Condition 3L, had 18, three-letter words. Number of repeated letters was essentially equivalent across all four lists.

Procedure and subjects. Group procedures were used with 30 subjects assigned to each of the four lists. Although each item in the variable list was presented twice on each simultaneous-learning trial, we still anticipated great difficulty in learning the syllables with low-association values. Therefore, instead of the usual two study-test trials, four

were given. The rate of presentation remained at 5 sec, with 2 min allowed for free recall. The subjects printed their recall attempts of the variable list. As usual, the standard task was always recalled first.

Results and Discussion

The four variable lists will be identified as V1 through V4 along the meaningfulness dimension. The mean total numbers of correct responses on the standard list during simultaneous learning were 17.24, 17.33, 15.02, and 14.37, for V1, V2, V3, and V4, respectively. It is obvious that the learning of the standard list was not influenced in the manner expected. The subjects did most poorly on the standard list when the variable list was made up of three-letter words, and best when the variable lists had 0 and 50% association value syllables. The differences across the four lists were reliable, $F(3, 116) = 4.07$, $MSe = 273.30$.

Many previous studies (e.g., Underwood & Schulz, 1960) had led us to believe that the four levels of meaningfulness would result in marked differences in learning the variable task. The mean total correct responses during the learning of the variable lists were 27.37, 33.83, 35.57, and 40.80, for the four lists in order. Although these means were correctly ordered, and although they differed significantly, $F(3, 116) = 10.12$, $MSe = 91.03$, the differences were certainly not as great as we expected. For example, after eight presentations of the list of 3-letter words, the mean number correct was 13.50, and after the same number of trials for the list with zero-association nonsense syllables, the value was 9.60.

One further matter should be reported. In all of the experiments we have routinely calculated the correlations between the learning of the two tasks in simultaneous learning, and in almost all cases we found these correlations to be high. The exception was in the present experiment. For Condition V1 the correlation between total correct on the standard task and total correct on the variable task was .14; for Condition V2, it was .27. But, for V3 and V4 the values were .78 and .87. One interpretation for the two low correlations is that the processes that underlie the learning of difficult nonsense syllables and five-letter words (standard task) are different. If the two types of lists do not require the same resources for learning, performance on both could have been enhanced because there would be no competition for learning resources. This would account for the higher performance on the standard task when V1 and V2 were the variable tasks than when V3 and V4 were the variable tasks. Also, if the learning of the nonsense-syllable lists V1 and V2 were enhanced, it explains why the effect of meaningfulness in this experiment appeared to have been attenuated.

Experiment 6

With this experiment there is some shift in method, although the basic intent remains the same. That is, we continue to ask about shifts in study time or attention as the difficulty of a variable task is manipulated. However, the subjects were tested individually and they were given four successive lists of the same structure to learn rather than a single list. The experiment carries two tests of factors involved in shifts in the allocation of resources.

The standard task was a free-recall list of four-letter words. The variable task in one case was a list of abstract words and in another a list of concrete words. As in the earlier experiments, we ask if performance on the standard task changes as a function of the differences in difficulty on the variable task produced by the concrete-abstract variable. This is the first test.

The second test deals with an account of the spacing effect. When (in free recall) items are repeated in adjacent positions (massed schedule) subsequent recall is poorer than if the repetition occurs in nonadjacent positions (spaced). One theory attributes the spacing effect to the attenuation-of-attention produced by the massed occurrences (Shaughnessy, Zimmerman, & Underwood, 1974). In effect, the theory holds that the processing of a massed item diminishes because of the attenuation-of-attention produced by the massing of presentations.

We will not summarize here the evidence concerning this theory, nor the evidence for competing theories. It will be noted that attention theory as applied to the spacing effect in the present study corresponds closely to the central problem we have been testing, because we ask about the circumstances under which subjects will reallocate their study time. The critical test of attention theory may now be described. In three instances within a list an item in the standard list occurs on four successive presentations (a heavily massed item). However, there are four <u>different</u> words from the variable task which occur with the heavily massed item. We may illustrate this as follows:

Standard Task	Variable Task
HOSE	piston
HOSE	infirmary
HOSE	instructor
HOSE	chloride

The subjects were under instructions to learn as many items from both lists as possible. If the subjects start to attenuate attention to the massed item in the standard task, they should redirect attention to the variable list and, in effect, spend more time studying the items in the variable task paired with the repeated item from the standard task than they would if the items in the standard task changed from presentation to presentation. As a consequence, recall of the four items from the variable list should be higher than the recall of control items (words that occurred once in the variable list but which did not occur with a massed item from the standard task).

Method

Lists. The items in the standard list were four-letter words printed in capital letters on the memory-drum tapes. There were four such lists, and 18 items were used in each. The functions of the 18 items in each list were as follows: 3 primacy buffers, 3 recency buffers, 3 occurring once within the body of the list; 3 items occurring twice by massed presentation; 3 items occurring twice by spaced presentation (varying lags), and 3 items that occurred four times by massing. To carry out this schedule, a list with 33 positions was required. Massed and spaced items occurring twice were included just to make sure that a

spacing effect would be found with the materials and simultaneous learning procedures used.

The above description applies only to the four standard lists. We may now describe the variable lists, four of which were made up of concrete words and four of abstract. All concrete and abstract words had at least six letters and at least two syllables, and were printed on the memory-drum tape in lower case letters. Thus the discrimination between the items in the standard lists and those in the variable lists could be made on the basis of type, of length, or of both.

Each of the four concrete lists and each of the four abstract lists contained 24 different words. The 108 abstract words were chosen from the list given by Paivio, Yuille, & Madigan (1968) as were the 108 concrete words, and the concrete and abstract words were matched word for word on Thorndike-Lorge (1944) frequency. The concrete words had scaled values of 6.0 or above, the abstract words had values of 3.0 or below. The functions played by the 27 words in each list were as follows: 3 primacy buffers, 3 recency buffers, 3 words occurring singly in the body of the list and serving as the controls for the test of attenuation theory; 3 items occurring twice under massing; 3 items occurring twice under a spaced schedule, and 12 items presented once with the three massed items occurring four times each in the standard list. Of course, this list also required 33 positions. It should be clear that the standard and variable lists were yoked to form the lists to be learned simultaneously, i.e., when an item in the standard list was given two massed presentations, so also was a word from the variable list. The only case

where there was no yoking was for the 12 presentations in which only three words were used for the standard list (3 items, each massed four times) and 12 items for the variable lists.

Item function was determined randomly, and assignment to list was random. The order of the four lists was the same for all subjects. The two words presented together for simultaneous learning occupied the same row; which preceded the other was random. The structure of the four lists differed somewhat, i.e., the placement of particular item types differed in minor ways from list to list (except, of course, for the primacy and recency items). The intent was to prevent the subject from developing an expectation of a particular pattern of items.

Procedure and subjects. Perhaps we should mention again that the subjects were fully instructed as to the nature of the materials, the number of lists, and so on, and that they were always told to try to recall as many items from each list as possible. The rate of presentation was 6 sec. The standard list (four-letter words) was always recalled first, followed by the variable list. The subjects were given 2 min to recall the standard lists, and 3 min to recall the variable lists. Immediately after the recall of the first variable list, the subject was given a study trial on the second list, then recall, and so on, until all four lists had been studied and tested.

A block-randomized schedule was used to assign 25 subjects to the simultaneous lists having concrete words and 25 to the simultaneous lists having abstract words.

Results and Discussion

Performance generally improved across lists, but the amount of improvement was essentially the same for the concrete and for the abstract lists. Therefore, we have summed the scores across the four lists for each subject. The first question concerns the recall of the standard lists as a function of the type of variable list (concrete versus abstract). The mean total recalls of the standard list were 27.12 and 27.36 for the concrete and abstract variable lists, respectively. It is obvious that there was no shifting of resources or reallocation of study time.

To expect a reallocation of study time would require that the concrete and abstract lists be of different difficulty. In fact, the differences were unexpectedly great, the mean total score being 19.44 for the abstract words and 32.48 for the concrete words, $t(24) = 3.46$.

We turn next to the data which will tell whether or not an expected spacing effect was found. Table 1 shows the recall scores for the massed and spaced items in each of the two lists. The standard task, of course, occurred with both the concrete and abstract lists so there are two tests of the spacing effect for these words. As may be seen in Table 1, in all cases the recall following spacing was substantially higher than the recall following massing.

The final results to be presented concern the tests of the attenuation-of-attention theory. In our original thinking about the test

of attention theory we thought that recall of the variable items paired with the quadruple massed items might be related in a simple way to the position held in the group of four. As a massed item repeats itself the likelihood increases that attention will shift to the concrete (or abstract) word with which it was paired. Thus, across the four concrete (or abstract) words, recall would increase directly. However, with the slow rate of presentation used (6 sec), the subjects are likely to rehearse other recently presented words from the variable list. Given this, we would not anticipate any simple relationship between learning and recall of the four words presented with the item massed on four successive presentations. Still, it seemed worthwhile to retain position as one variable.

The results are plotted in Figure 6. The control baseline represents the recall of the three words presented once within the body of the lists. Insofar as the recall of the experimental words is above the recall of the control words, the results must be considered favorable to the attention theory. Statistically, we first asked if recall of the experimental words was in fact better than the recall of the control words, as seems to be indicated by Figure 6. For the concrete words the mean difference produced a $t(24) = 3.63$, and for the abstract words, $t(24) = 3.15$. As a second step an analysis of variance was performed on the scores for the experimental words, maintaining position as one variable and concrete-abstract as the other. The outcome showed the concrete-abstract difference to be reliable, $F(1, 48) = 6.55$, $MSe = 9.58$, as was also position,

Table 1

Mean Total Number of Items Recalled as a Function of Type of Word and Massed vs. Spaced Practice

	Abstract			
	Massed		Spaced	
	M	σ	M	σ
Four-Letter Words	3.76	1.63	5.40	1.92
Abstract Words	2.12	1.45	3.08	2.00

	Concrete			
	Massed		Spaced	
	M	σ	M	σ
Four-Letter Words	3.12	1.99	5.52	2.32
Concrete Words	3.52	2.53	5.52	2.86

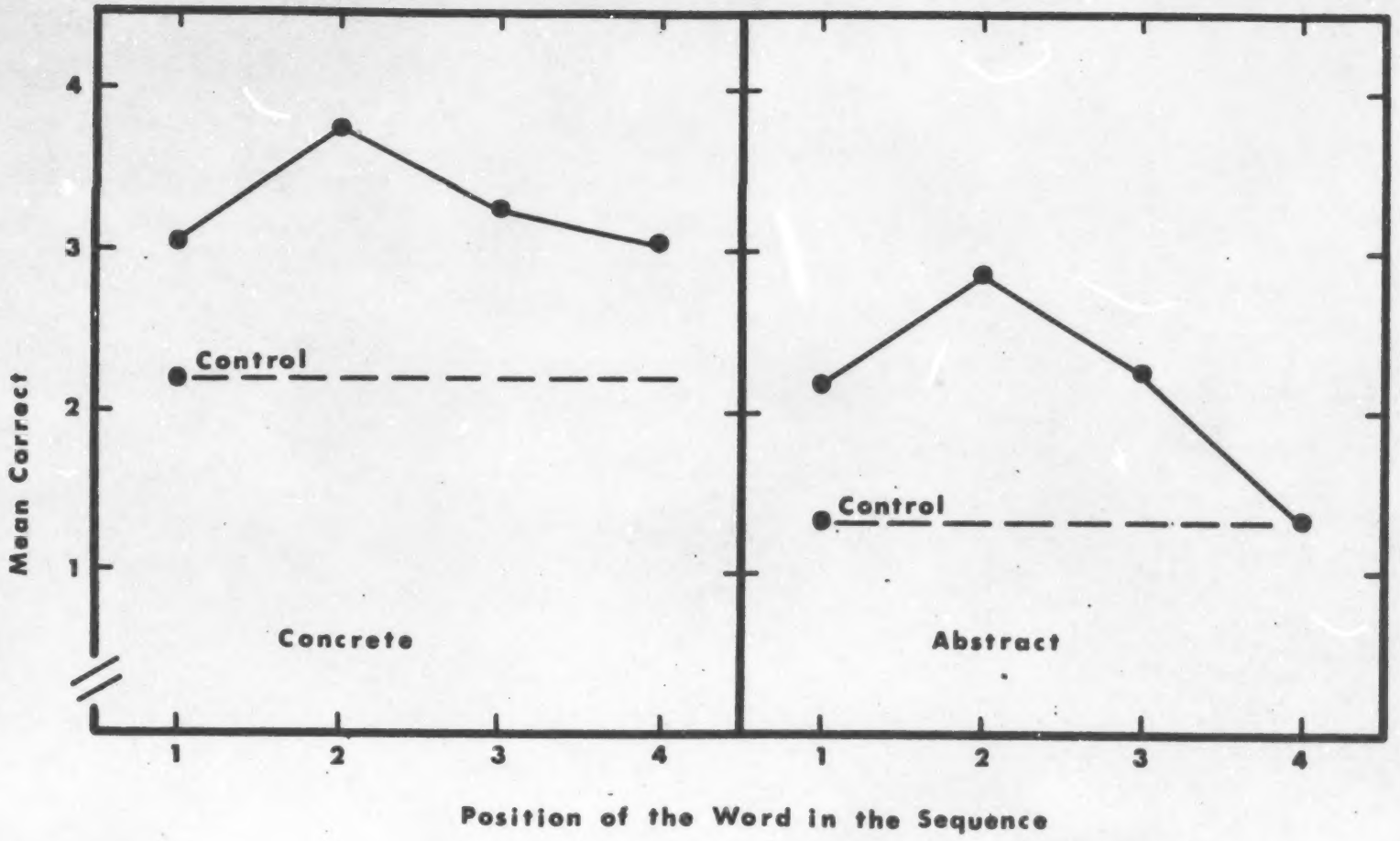

Figure 6. Correct recall of the variable task as a function of the position of a repeated word in the standard task. See the text for a complete explanation. Experiment 6.

$F(3, 144) = 5.56$, $MS_e = 1.93$. The interaction was not reliable ($F = 1.21$).

It appears to us that the differences in recall as a function of position represent the results of complicated rehearsal patterns, although we have no evidence that can be given to support this position. The critical finding, however, is that the recall of the experimental words is higher than the recall of the control words, a finding that may be used in support of the attenuation-of-attention theory for the spacing effect.

Experiment 7

The final two experiments were directed toward two issues that arose as the other experiments were being carried out. The issue dealt with in Experiment 7 has to do with the role of intentionalty in simultaneous learning. We have assumed that the learning of the standard and variable tasks that we have observed results from the subjects attempting to learn both lists. It is possible, however, that appreciable learning of one list could occur if the subject was attempting only to learn the other list. In attempting to learn only one of the lists, the subjects must necessarily select out the appropriate items for learning, but in this selection process it seems beyond doubt that they may perceive many of the items from the list that they have no intention of learning. Insofar as perception is an initial stage in learning, it might be expected that instructing the subjects to learn only one of the tasks would lead to considerable knowledge about the other. Experiment 7 examined this matter.

Method

There were three conditions in the experiment. First, there was the

usual simultaneous learning condition in which the subjects were instructed to learn as many of the items from both lists as possible. This will be called Condition SV (standard-variable). The two lists used were the two from Experiment 1. Condition SV establishes the level of learning of the standard task when the subjects learn both lists simultaneously. To establish the maximum amount of learning that could occur for the standard list, it was presented alone at a 5-sec rate, the same rate used for simultaneous learning. This condition is identified as S Only. The third condition will be called Condition SV Inc. In this condition the subjects were presented both lists simultaneously just as in Condition SV but they were instructed that they were to learn only the five-letter words: "When I start the projector you will notice that on each slide there is a three-letter unit and there is a five-letter unit. You are only required to learn the five-letter units." If merely distinguishing between the two sets of words is a major component of simultaneous learning, performance on the standard task under Condition SV Inc. should be much lower than the performance by the subjects in Condition S Only in which only the standard task is given. Furthermore, a considerable amount of incidental learning of the variable list (three-letter words) would be expected. If, on the other hand, distinguishing between the two sets of words is a minor matter, performance on the standard task would be little impaired in Condition SV Inc, and incidental learning of the variable task should be low.

Two study-test trials were given. After the second test trial on the standard list for the subjects in Condition SV Inc, the subjects were

asked to write as many of the three-letter words as possible: "Even though you did not have to learn the three-letter units, we have reason to believe that mere exposure to the units resulted in some learning. I would now like you to try as hard as you can to remember as many of the three-letter units you saw as possible."

There were 30 subjects in each of the three groups tested by a group-learning procedure as described for the earlier experiments.

Results and Discussion

The recall of the standard list for the three groups on each trial is shown in Figure 7. The results are quite definitive. That performance under Condition S Only is better than that under Condition SV simply shows that the simultaneous learning of the standard task is much easier when presented alone than when it must be learned with another task. The subjects in Condition SV Inc performed almost as well as those in Condition S Only. Statistically, the groups did not differ, $F(1, 58) = 1.23$, $MS_e = 95.90$, indicating that selecting the five-letter words for learning and ignoring the three-letter words is of little consequence for performance. If this selection process is as easy as Figure 7 suggests, it must follow that the amount of incidental learning that occurred should be minimal. This was the case, the mean correct recall of the three-letter words being 2.53, with a range of from 0 to 6.

The data as a whole lead to the conclusion that distinguishing between the two lists during simultaneous learning is a minor factor in the overall

learning process. Indeed, when simultaneous learning is involved, there is no particular reason why the subjects cannot simply learn all items without categorizing them until recall is requested.

Experiment 8

The logic of Experiments 1 through 6 was that a subject during simultaneous learning will allocate study time, or more generally perhaps, learning resources, so as to maximize total recall. For this to be done, some judgments have to be made by the subject about the relative difficulty of the two lists. We have assumed that across conditions, in which the difficulty of the variable list was changed, the perception of relative difficulty would also be different. Thus, perceived difficulty was always relative to the standard task. If one group of subjects had to learn a list of abstract words along with the standard task, and another group a list of concrete words along with the same standard task, we assumed that the group having the concrete words would judge this list to be relatively easier than would the group having the list of abstract words.

It might be argued, perhaps, that our failures to find that performance on the standard task did not change as difficulty of the variable list changed was due to the lack of sensitivity to differences in difficulty when this sensitivity depended upon the judgments of different groups of subjects. Perhaps if a subject were given all conditions of difficulty, far more shifting of resources would occur than observed in the preceding experiments. Experiment 8 made an assessment of this possibility.

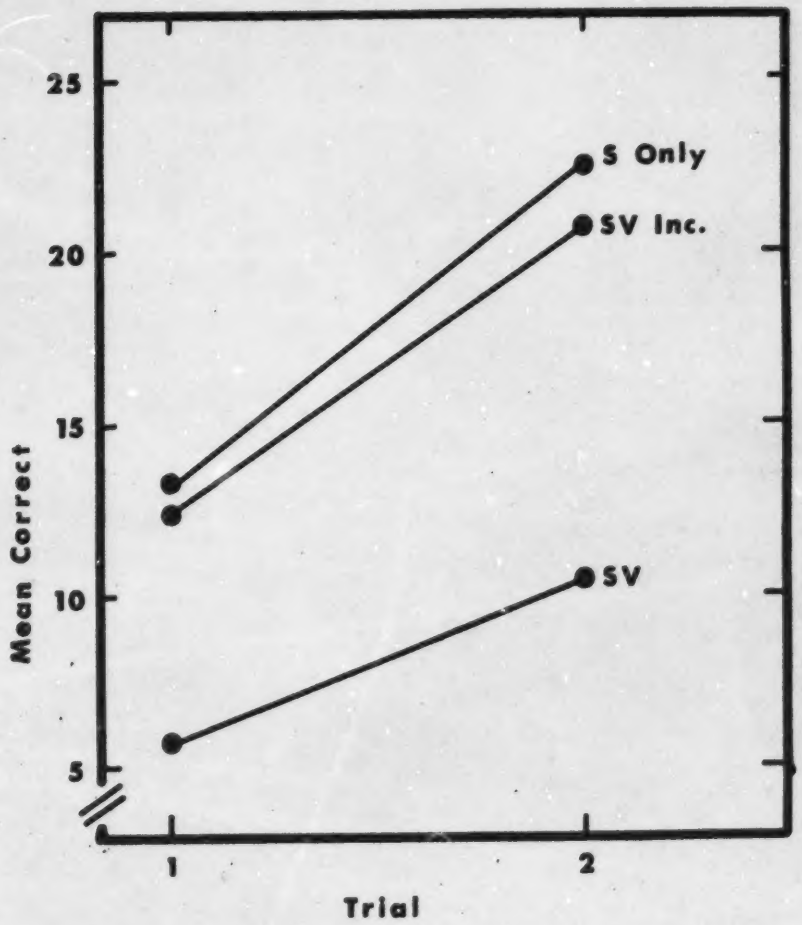

Figure 7. Correct recall of the standard list during simultaneous learning (SV), when the standard task only is learned (S only), and when both lists are shown but only the standard task is learned (SV Inc.). Experiment 7.

Method

Lists. The standard list consisted of 24, four-letter words, and the variable list was made up of either concrete words or of abstract words. All of the lists came from the same pool of words used in Experiment 6. It may be remembered that large differences in learning the abstract and concrete words occurred in simultaneous learning in Experiment 6, but that the learning of the standard task was uninfluenced during simultaneous learning by the nature of the other list (abstract or concrete). For the present experiment the lists consisted of 24 items, and the subjects again distinguished between the items in terms of length (four-letter, monosyllabic words versus words with two syllables or more and six letters or more).

Conditions. There were four conditions and in all four the subjects were given two successive simultaneous lists to learn, each for two trials. In Condition CA the first simultaneous list had concrete words for the variable list, whereas the second simultaneous list had abstract words as the variable task. Thus, a given subject, having experienced concrete words on the first task would presumably notice the increase in difficulty of the "long" words on the second task as compared with the first. A reduction in study time allocated to the standard task might result, which in turn would result in a drop in performance on the standard task. As a control for Condition CA, Condition AA had abstract words in both simultaneous tasks. There might be changes in allocation of study time merely as a consequence of having two lists to learn, so that performance on the standard task for the second simultaneous list must differ for Condition CA

and Condition AA. Condition AC had abstract words in the first list, and concrete in the second. Again, the contrast in difficulty of the long words should be apparent to the subjects in moving from the first to the second list and study time for the standard list might be reallocated, with more time given to the standard list than was given on the first task. As a control for Condition AC, a fourth group was given Condition CC in which the long words were concrete in both lists.

Although the two lists of four-letter words were made up by choosing words randomly from a pool, we also counterbalanced these two lists so that each occurred equally often in the two positions. The concrete and abstract lists were made up by assigning items randomly from the pools.

Procedure and subjects. The subjects were fully instructed about the characteristics of the lists before the lists were presented for learning. The lists were presented at an 8-sec rate by memory drums. The standard list was always recalled first with 3 min allowed for the recall of each list. The procedures were exactly the same for both trials on a list. Each of the four conditions was represented by 20 subjects assigned to the conditions from a block-randomized schedule.

Results

The critical data lie in the recall of the standard tasks for the two lists. In no case were interactions with trials found; therefore, all data to be presented were mean total correct responses across the two study-test trials. Figure 8 gives the mean number of correct responses

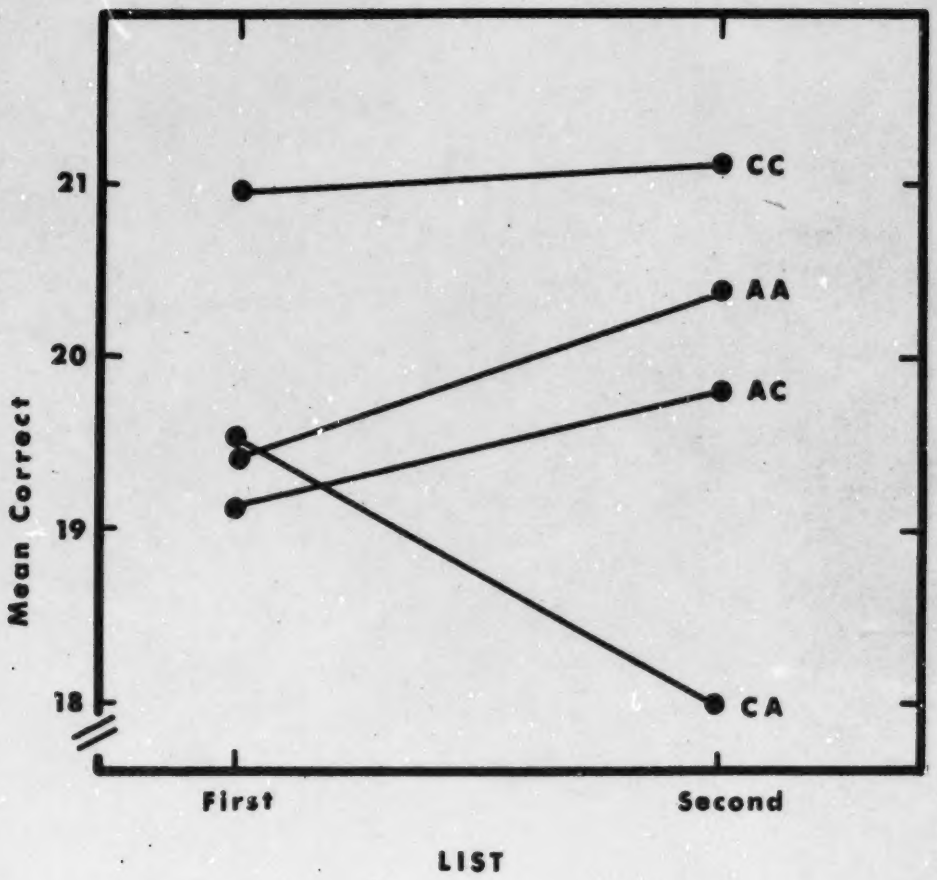

Figure 8. Correct recall of the standard task when the subjects learned two successive simultaneous lists. The letters C and A refer to concrete and abstract and they represent the nature of the variable lists in the two simultaneous lists. Experiment 8.

from the standard list for the four conditions for the two simultaneous lists. Although it may appear that substantial differences were found between the conditions, this was not supported by the statistical analysis as will be apparent shortly.

Data for the first list learned gives evidence on reallocation of resources of the same nature as that presented in Experiment 6, and the conclusion is the same. Because the four groups do not differ on the first list, $F(3, 76) = .37$, $MS_e = 35.12$, it is concluded that study time was not altered as a function of the ease of learning the variable task. The data for the second list tell whether experience with variable lists of both levels of difficulty influence performance on the standard list. Because performance on the standard task falls between the first and second list for Condition CA it would seem to support the idea that subjects allocated more time to the variable abstract list than they had to the variable concrete list just learned previously. However, the differences are quite unreliable. An analysis of variance for the four conditions on the second list did not allow rejection of the null hypothesis ($F = .93$). Furthermore, t tests between Conditions CA and AA (1.18), and between Conditions AC and CC (.71) for the second list indicated that the differences were of no substance. These data, therefore, are taken to indicate that our failures to find reallocation of study time as the difficulty of the variable task changed was not due to the fact that the subjects had not experienced the different levels of difficulty.

For the above conclusion to hold, of course, differences in learning as a function of the concrete-abstract variable had to be observed.

They were. The subjects in Condition CA had a mean of 17.35 and 11.60 correct responses for the concrete and abstract lists, respectively, $t(19) = 5.13$. That the differences were not influenced much by learning-to-learn is shown by the fact that for Condition AC the values were 18.55 correct responses for the concrete list and 11.95 for the abstract, $t(19) = 5.41$. Between-groups measures of the learning of concrete and abstract lists can be obtained by comparing scores for Condition CC with those for Condition AA. For the first list the means were 17.70 and 12.30 for the concrete and abstract lists, $t(38) = 2.46$, and for the second list the corresponding means were 18.90 and 12.65, $t(38) = 2.59$. We conclude that large differences occurred in acquiring the abstract and concrete lists during simultaneous learning. These differences in difficulty, however, appeared to have no influence on the allocation of study time by the subjects.

General Discussion

In the experiments reported we asked about the interaction between two lists learned simultaneously. The interaction of primary interest was the change in the allocation of study time (or learning resources) as a function of the difficulty of the variable task with the standard task held constant. The results divide themselves into two major groupings. First, when task variables were used to change the difficulty of the variable task there was little influence on the performance on the standard task. That is, as the variable task became more difficult, there was not a corresponding decrease in performance on the standard task. This has been interpreted to mean that the subjects did not allocate more study

time to the variable task as it became more difficult. Second, we inferred that there were substantial shifts in study time when the difficulty of the variable task was changed by having various numbers of preliminary trials, and somewhat lesser shifts when the number of repetitions of the words in the variable task was manipulated, holding total presentations constant.

As noted above, the changes produced in the difficulty of the variable lists by manipulating task variables had no apparent influence on the learning performance. It is true that the differences in difficulty produced by the task variables were not always large, but even when they were large (as in the case of concrete versus abstract words) there appeared to be no influence on learning strategies. We cannot, of course, insist that the subjects did not change strategies, but we can say that if strategies were varied there was not a concomitant change in our measures.

Another approach to the results dealing with task variables is to argue that the subjects could not detect the differences in the difficulty of the variable lists, hence there was no reason for shifts in strategies. We think this position can be rejected for most of our experiments. It has long been known that subjects can predict the relative difficulty of items with considerable accuracy (e.g., Underwood & Schulz, 1960). There is no reason to believe that our subjects could not assess relative difficulty validly, and did so. The facts seem to indicate that the subjects did nothing about it when they did detect differences. Experiment 8 was particularly clear with regard to this issue.

There may be an exception to the above generalizations. When difficulty of the variable task was manipulated by varying meaningfulness, we found that a reverse effect was found in that the higher the meaningfulness the more poorly the subjects performed on the standard task. These differences were not large, but in conjunction with correlational evidence, they led us to propose that the processes underlying the learning of common words and low association-value nonsense syllables were quite different. As a consequence (according to our interpretation) there was no competition for common learning resources, and the syllable lists were learned more rapidly than anticipated as was the standard list of words. If this interpretation is correct, it can be seen that simultaneous learning of two such uncorrelated tasks could occur without a negative factor being assigned to simultaneous learning per se. By this is meant that if simultaneous learning of the two tasks takes place at a 6-sec rate, the amount of learning of each task would be the same as that observed when each was presented alone at a 3-sec rate. We have not found it possible to make this test as yet.

It will be remembered that in Experiment 2 word frequency was manipulated as the variable task. On the first simultaneous learning trial, word frequency had no effect on the learning of the variable task although it did have the expected influence on the second trial. This suggests that subjects might have tried a particular strategy on the first trial that neutralized the effects of word frequency, but abandoned this strategy after the first trial. We do not know what such a strategy might be.

Had we only carried out the experiments in which the task variables were manipulated we would have had to conclude that subjects are not easily influenced to reallocate study time or learning resources as the difficulty of the variable list changes in simultaneous learning. Experiment 8, where the subjects learned two successive simultaneous lists, made this quite evident. However, two other experiments showed beyond doubt that subjects could be made to reallocate learning resources when the independent variable produced differences in difficulty of the variable task by changing its level of learning within the experimental situation. We refer to the results for Experiments 1 and 4, with the latter being particularly clear on this matter. Those results showed that the greater the number of preliminary learning trials given on the variable task before simultaneous learning the faster the learning of the standard task during simultaneous learning. With five preliminary trials on the variable list, the subjects essentially ignored the variable list during simultaneous learning, apparently allocating nearly all of the time to the standard list.

One further situation apparently produced a shift in the allocation of resources. In Experiment 1, subjects who knew they would have to recall the words in one list and be tested for recognition on the other list, spent more time studying the list to be recalled than the one to be tested by recognition. At least this seemed to be a reasonable inference from the data because recall was higher in simultaneous learning when one list was to be recalled and the other to be tested for recognition, than when both were to be recalled. This effect was not large and in the

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two cases in which it was observed, the statistical reliability was present for only one of the two. We interpret these results to indicate that subjects may accept the idea that recognition constitutes an easier task than recall. As a consequence, they spend more time studying the items to be recalled than those to be tested by recognition.

Finally, some of the data for Experiment 6 led us to conclude that subjects reallocated study time for a still different reason. When the same word occurred in four successive positions during simultaneous learning, the four different words occurring in the other list were far better recalled than were control items. Our interpretation was that as the item in the one list repeats itself, attention to it is attenuated, and the subjects spend most of the study time on the nonrepeated words. If this interpretation is appropriate, it means that under certain conditions the subjects will reallocate study time or learning resources between the two lists several times during the course of a single trial.

Our general conclusion is that when subjects are given a simultaneous learning task they assign a certain amount of learning space or learning resources to each as they attempt to follow the instructions to "learn as many items from each task as possible." We suspect this allocation is about 50:50 under normal circumstances, and we also suspect that the initial allocation remains fairly stable over the initial trials. Only when some very obvious differences in difficulty between the two tasks occur will the attention be directed primarily to the more difficult task.

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